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Mid-Rise Atrium Residential Houses - Domain of Comfort

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Abstract. The paper discusses the role of a natural landscape in an industrial city, the harmonious interaction of an architectural object and the environment in creating a unified eco-architectural space. The authors focus on the typological aspect of residential architecture development, the feasibility of introducing low-rise complex development in the urban environment, suggesting the use of a morphologically autonomous category of urban villas as a type of residential building. The paper considers the advantages of a sustainable and presently relevant spatial archetype – an atrium – and its inclusion in the structure of a residential building and the eco-technical direction of its use along with separate engineering and technical solutions within the concept of energy saving. As an example, a low-rise residential complex project of an ‘urban apartment villa’ typological structure is considered, with the use of a multi-comfortable house system and the atrium principle of internal space organization in order to create an eco-friendly residential environment in the context of urban development and natural landscape.

1. Introduction

The general tendency for the development of urban areas and the growth of cities as a whole is accompanied by an increase in building density due to construction of high-rise buildings and concentration of urban infrastructure, including transportation systems, which leads to a deterioration of the ecological climate, living conditions and an increase in psychological stress in society. Within the development of the prestigious areas with new residential buildings, especially in the city centre, it is important to consider the ratio of the area and number of floors of buildings, the importance of landscaping and amount of vegetation in the area, the natural and urban context of the site, bioclimatic factors, object typology, and, of course, the possibility of applying modern "green building" technologies. This determined the goals and objectives of the study project: Residential complex "Zelenyj bereg" in Yekaterinburg.

2. Location

As a site, a triangular area was selected, bounded by Belinsky and Furmanov streets and the bank of the Iset River. The site is currently undeveloped and is intended for residential development. A complex of townhouses is located on the opposite side of the river, which determined the scale of nearby development. Municipal and industrial facilities located along the bank are gradually being



moved outside the city, freeing up the territory for residential high-rise buildings, emphasizing the guest route at the entrance to the city center.

2.1. River

Modern cities commonly began their history on the banks of rivers that served as transport routes and sources of water. Later, with the development of industry, the first factories and settlements grew along the rivers. The water area not only provides the city with a possibility for growth but is its center of attraction and a place of rest for inhabitants. The task of reviving and preserving the city's water landscape is also very relevant for Yekaterinburg: how to use the banks of the Iset river harmoniously and wisely, whether it is worth reserving the banks exclusively for recreation of citizens or use for construction, and how to link the scale of a small river to the scale of the surrounding buildings and the industrial city as a whole.

3. Typology

The choice of the type of building as a mono-space for the formation of a complex of buildings as part of an urban structure, is connected in this case with the urban planning (place) and natural (river) context, which determined the typological choice – a low-rise residential complex with a mixed urban structure "urban apartment villa" [1, 2]. Preserving all the advantages of individual housing and the continuity with the house-villa in its traditional sense, this type of residential building today has become an actual model of a modern residential and urban structure. This largely determines the very idea of an "ideal" home: first of all, the combination of comfort and privacy with the possibility of organizing public spaces, taking into account its small scale - the introduction of modern "green" technologies and energy-saving systems. The urban apartment villa has the economic advantages of a mid-rise apartment building: the building's wide-body, even with this number of floors, the compact organization of space, moreover, multi-factor loads on residential areas are reduced compared to high-rise buildings. The mixed structure of the building determines the variety of space-planning decisions of apartments, creates opportunities for the integration of landscape design into the border areas (landscaping of house sections, walls, roofs and terraces) and the interior spaces of a residential building.

3.1. Atrium

Atrium, as an alternative principle of the structural organization of space, has great functional and environmental potential [3, 4]. The atrium, as well in a residential building, is a multi-luminous integral space, mostly socially-communicational, that provides connection and relaxation of the inhabitants within the common area. As well it serves as a mean of increasing the compactness of the building and integrated residential development as a whole. With profound solutions and rational use of the atrium structure, the issues of building energy efficiency, creation of optimal microclimate and comfort of the internal environment are resolved. Among the aspects that shape the structure of modern buildings, the important one is creation of an effective ecosystem of the internal space, including the provision of natural ventilation and natural lighting, heating and cooling of rooms depending on the season and climatic conditions. In this regard, the atrium, as a historically stable model of the organization of the architectural space [5], as well as the general ecotechnical concept of the buildings, can significantly affect the level of comfort of the internal environment. In this case, two physical effects are considered: the greenhouse effect and the effect of dynamic traction [6]. It is the greenhouse effect that allows you to retain heat from sunlight and heat radiation from the inside in the atrium's space, which positively affects the microclimate in winter, but negatively in summer. Consequently, the use of the atrium features can be considered in two ways:

- in the winter, the internal air is heated due to the used air, and in the summer it is cooled due to natural ventilation;

- air exchange and natural ventilation are provided due to air traction. In general, this space is considered as an air reservoir and a “ventilation duct”.

The principles of organizing natural ventilation in the atrium space are actively used in energy-efficient buildings, in an appropriate form, depending on the time of year and climate.

3.2. Comfort

In the twenty-first century, people will need a completely different standard of living. A “multi-comfort” house is the perfect home in terms of living comfort and maintaining an optimal indoor climate (comfortable temperature and humidity) with the “smart house” system. The environmental component in this context should be the creation of a multi-comfort environment in a “passive” house.

3.3. Energy efficiency

The energy efficiency of the house in the building construction and operation practice aims to reduce the level of energy consumption throughout the entire life cycle of the building. “Passive” is a house in which the energy consumption for heating is minimized (down to zero) with the help of internal heat sources, modern energy-saving technologies and highly efficient heat-insulating materials [7-9]. In such a building, all energy processes should be optimized. From modern standards, truly energy-efficient houses are the ones that have enough energy from individual renewable sources for hot water supply and heating. The specific heat energy consumption for heating a passive house, determined using the “Passive House Planning Package” (PHPP), should not exceed $15 \text{ kW}\cdot\text{h}/(\text{m}^2\cdot\text{year})$. The total consumption of primary energy for all domestic needs (including heating, hot water and electric energy) should not exceed $120 \text{ kW}\cdot\text{h}/(\text{m}^2\cdot\text{year})$. Moreover, the passive house should be comfortable in the summer without the use of an air conditioner!

In the case of designing a low-cost passive house, the main points should be considered: improvement the thermal insulation of standard building elements (roof, walls, floors), reduction of thermal bridges, sealing of building’s shell, usage of special windows for passive buildings, efficient heat recovery from exhaust air.

4. Design decisions

As a result of the analysis of the selected situation, taking into account a number of factors, a general project concept was developed, consisting of three main areas.

4.1. Urban planning concept

Urban planning concept:

- improvement of the river bank – the creation of a promenade with the competent use of the natural landscape;
- residential development – urban apartment villas as a transition from the scale of a low-rise residential complex on the opposite bank of the river to a multi-story development of adjacent territories;
- compositional development solution – includes landscaping of the residential complex and terraced construction of the coastal promenade, taking into account its natural context (scale and bending of the river, shoreline geometry, existing terrain) and providing clear functional zoning of the site and autonomy, while maintaining convenient interconnections;
- privacy and comfort – location of urban villas away from noisy highways on the upper level of the coastal relief, “protected” by high-rise buildings along the front of adjacent streets,

preserves the privacy of the home, the psychological and environmental attractiveness of the site, and, taking into account the low density of the building, creates comfortable living conditions.

4.2. Spatial decisions of a residential building

The idea behind a compositional and space-planning solution of a residential building is the desire to harmoniously combine urban planning and natural surroundings with the typology and principle of organizing living space. The urban apartment villa with the combined planning structure and an internal atrium has a complex shape: a sculptural form and the “opening” of the volume towards the river and the straight geometry of the volume from the urban area. The planning structure is conditionally divided into three “radial” functional zones: a central atrium hall with a minimum external fencing area (ideal for thermal protection, an atrium model) [10] and upper glazing; buffer zones of utility rooms located around the hall and residential apartments zone (figure 1). Apartments with the number of living rooms from 1 to 5 have spacious loggias and balconies with container gardening, which compensates for the advantages of an individual dwelling. Ground floor apartments have own entrance from landscaped terraces. Hall-atrium with floor galleries, open green roofs, various public premises on the 1st floor, including a billiard room, mini-kindergarten and fitness center form a single recreational and communication public space of the “club” house, which largely shapes the nature of the communication of its inhabitants. The constructive solution of the building provides the flexibility of the internal space and the possibility of individual planning decisions in each apartment and redevelopment options during inhabitation. To save territory, ensure environmental safety and increase the comfort of living, a unified underground automated parking for personal vehicles is provided in the complex.

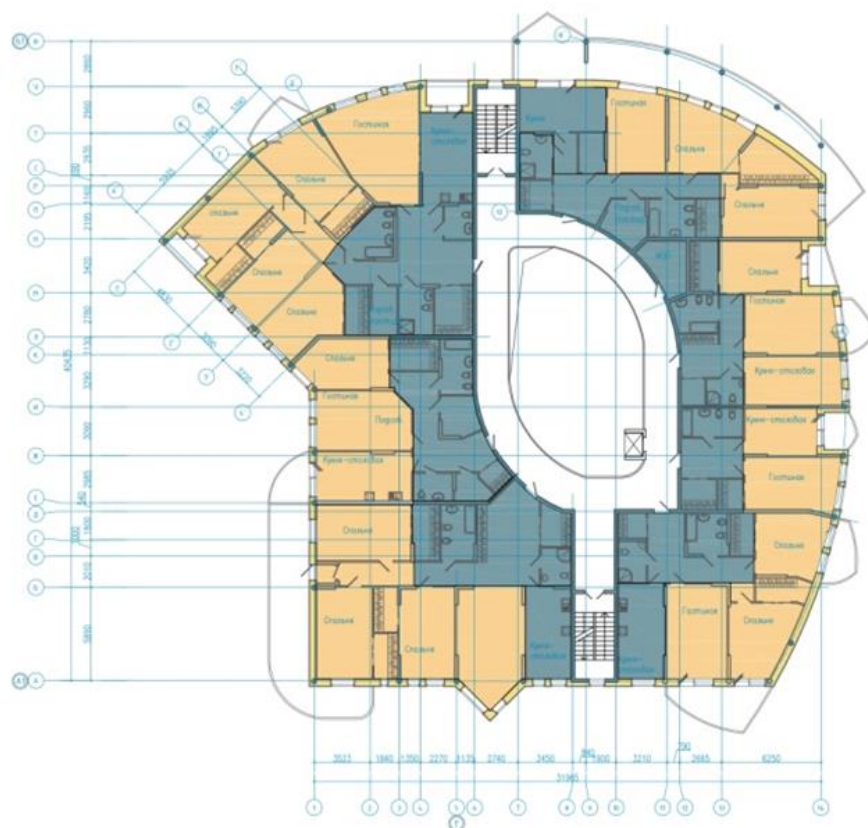


Figure 1. Floor plan: yellow - living rooms; dark green - bathrooms and corridors.

4.3. Energy-saving concept

The project adopted modern energy-efficient technologies. Solar collectors located on the operated roof contribute to the production of thermal energy, the excess of which is accumulated and stored in seasonal and daily heat accumulators. “Solar trees” are a source of electric energy, they are formed from arrays of innovative rotating solar batteries (cones with a power of 1000 W). They harmoniously fit into the environment and the energy supply from one tree is 9383 kWh per year. The project also proposes the use of a ground heat exchanger.

The elimination of cold bridges in monolithic concrete at the loggias joint was made based on Schoeck solutions, which reduces heat loss, prevents condensation and the development of the mold.

The windows of passive buildings work like solar collectors - heat from the passive use of solar energy makes the main contribution to the compensation of heat loss. Roller blinds with an automated control system SomfyAnimeoIB + allow optimal control of heat input and loss during interaction with the ventilation system. According to the principles of designing energy-efficient houses, the thickness of thermal insulation with a heat conductivity coefficient $\lambda = 0.04 \text{ W/(m}\cdot\text{C)}$ should aim for 40 cm (min 25 cm), and the heat transfer resistance should be 10. The project adopted a thickness of insulation in the outer walls of 40 cm, in the coating (more efficient insulation) – 30 cm. For comparison: the required thickness of the thermal insulation of a residential building, as calculated in the Urals, is 170 mm. Of course, this is a large thickness of insulation, but only by following this path, it is now possible to achieve small heat losses at an affordable price.

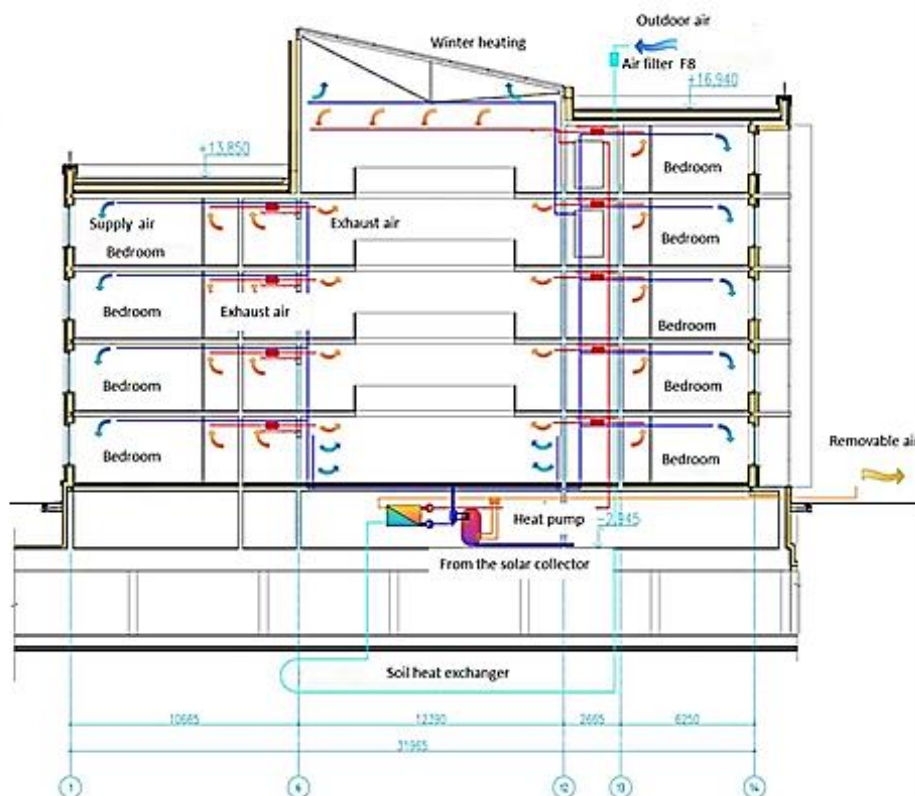


Figure 2: Ventilation scheme.

The ventilation system (figure 2) is divided into three zones: the first is the air supply zone for residential premises, the second is the transitional zone around the perimeter of the utility rooms, hallways, corridors, stairwells located around the atrium, the third zone is the exhaust air zone where

all wet rooms are connected. The used air from domestic premises is sent to the atrium, due to which additional heating of the air in it is carried out. The second important condition remains that the ventilation unit, if certain requirements for its maintenance are followed, serves primarily for air hygiene. Also, the use of recuperators will provide our building with a high share of heat recovery (more than 75%), which is a prerequisite for passive buildings

5. Conclusions

The following engineering and technical decisions were made in the project:

- modern environmentally friendly building materials and structures are used to create an environmentally sustainable living environment;
- independent energy sources are used for the effective functioning of all engineering systems of a residential building;
- continuous insulation building envelope principle is applied;
- installation of green roofs and container gardening of terraces and loggias using latest technologies in this area.;
- residential development.

Today, housing in Yekaterinburg impresses with its scale and pace of development. It is important that our houses are not only comfortable, beautiful, energy-efficient but also that they organically fit into urban development and the natural landscape since it is the architect who must teach the inhabitants the language of landscape and communication with nature.

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